



2 **Method for producing a three-dimensionally formed armoring  
3 component for vehicle bodies**

4

5 The invention relates to a method for producing a three-  
6 dimensionally formed armoring component for vehicle bodies by  
7 the production of sheet metal preforms from hardenable steel,  
8 with the thermal pre-treatment of these steel sheet blanks,  
9 the heating speed and heating temperature being selected until  
10 the austenitic state dependent on alloy content is reached,  
11 and with subsequent press forming and hardness treatment of  
12 the formed armoring components. Technical solutions of this  
13 kind are required, for example, in the motor vehicle  
14 construction of armored limousines.

15

16 In the production of special protective vehicles, armorings  
17 are used which are inserted into the outer planking of vehicle  
18 bodies. Since high-grade steels are difficult to process,  
19 these armorings are mostly designed as welding subassemblies.  
20 The known susceptibility to distortion and the considerable  
21 temperature sensitivity, which may bring about a decrease in  
22 strength even above a temperature of 200°C, often lead to  
23 crack formations and stress problems in the direct weld seam  
24 region and to strength problems in the heat influence zones.  
25 These undesirable effects rise with an increasing content of  
26 alloying elements and armoring hardness. This leads to an  
27 impairment of the protective effect required.

28 The production of three-dimensional components by hot forming  
29 with subsequent heat treatment is known.

30 Thus, DE 198 21 797 C1 discloses a method for the production  
31 of hardened parts from steel. This method serves particularly  
32 for obtaining preliminary products which, for example for the  
33 production of rolling bearings and transmission parts, on the  
34 one hand, are particularly resistant to fatigue, have a high  
35 load-bearing capacity and are wear-resistant and, on the other  
36 hand, are to be capable of being produced particularly  
37 adaptably in the interests of minimal mechanical remachining.  
38 For this purpose, an air-hardening steel is used, which is

1 obtained after heating to at least 1100°C first with hot  
2 forming to a temperature of at least 800°C and then with  
3 cooling by means of air to about 280°C, at the same time with  
4 thermomechanical treatment by calibration, subsequent cooling  
5 in air to room temperature and final expansion treatment at a  
6 temperature of 150 to 250°C.

7 Furthermore, US 5, 454, 883 A discloses a method, with the aid  
8 of which hardened steel plates are produced in that the  
9 heating rates during thermal treatment and the holding times  
10 at selected treatment temperatures are optimized. Moreover, in  
11 a variant, this technical solution suggests dispensing with  
12 calibration during the cooling of the components.

13 The common shortcoming of the known technical solutions is  
14 that they are unsuitable for the production of  
15 three-dimensionally formed sheet metal preforms from  
16 hardenable steel sheets, particularly when a cutting surface  
17 retreatment of the hardened sheet metal preforms is to be  
18 avoided. To that extent, the known technical solutions for the  
19 production of semifinished products, such as are required in  
20 mechanical engineering for the production of high-strength  
21 steel structures, highly load-bearing structural machine  
22 elements in the form of rolling bearing parts and transmission  
23 parts, are unsuitable for the production of  
24 three-dimensionally formed armoring components for vehicle  
25 bodies.

26  
27 The object, therefore, is to provide a technical solution,  
28 with the aid of which the shortcomings of the known prior art  
29 are overcome. In particular, a method is to be developed which  
30 is suitable for the production of armoring components for  
31 vehicle bodies, while avoiding weak points in the armored  
32 region. The armoring components are to be capable of being  
33 produced as comparable welded structures with repeating  
34 accuracy and markedly lower dimensional tolerances along with  
35 minimized remachining requirements.

36  
37 The object is achieved, according to the invention, by means  
38 of the features of claims 1 and 2. Advantageous refinements

1 are described in the subclaims. Accordingly, the method  
2 provides for the production of a three-dimensionally formed  
3 armoring component for vehicle bodies by the production of  
4 sheet metal preforms from hardenable steel. For this purpose,  
5 the steel sheet blanks are thermally pretreated, the heating  
6 speed and heating temperature being selected such that the  
7 austenitic or partly austenitic state dependent on alloy  
8 content is reached. In the austenitized state, the predominant  
9 part of the alloying elements contained in the material of the  
10 steel sheet blank is dissolved in the austenite. During  
11 austenitization, the heat treatment time is selected as a  
12 function of the carbon content, of the quantity and type of  
13 alloying elements and of the sheet thickness, such that  
14 scaling, skin decarburization and grain growth are minimized.  
15 Thereafter, press forming takes place, with subsequent heat  
16 treatment, if necessary, as a result of which the desired  
17 three-dimensionally formed armoring components are obtained.  
18 The method provides for carrying out the hot forming and  
19 quench hardening of the steel sheet blanks in one operation.  
20 The austenitized steel sheet blank is formed by means of a  
21 press die as immediately as possible, preferably still in the  
22 austenitic or partly austenitic state, and, as a result of the  
23 high cooling rate which is aimed at, the desired hardness  
24 structure in the formed steel sheet blank is achieved.  
25 The required critical cooling rate is in this case selected  
26 such that a hardness structure is obtained.  
27 After the closing of the press die, the formed component is  
28 held in full-area contact with the press die. The full-area  
29 contact of the formed steel sheet blank with the press die  
30 ensures the avoidance of deformations as a result of thermal  
31 stresses up to the partial or complete structural  
32 transformation of the formed steel sheet blank and serves for  
33 producing the required hardness structure in all the part  
34 regions of the armoring component generated. Weak points  
35 within the armoring component are consequently reliably  
36 avoided.  
37 The cooling of the formed component is an integral part of the  
38 hardness treatment and therefore takes place in the closed

1 press die.

2

3 Preferably, the forming in the press die takes place such  
4 that, during a pressing operation, with the formed steel sheet  
5 blank bearing over its full area against the impression of the  
6 press die, the rate of cooling of the austenitized or partly  
7 austenitized steel sheet blank is as far as possible above the  
8 critical cooling rate.

9

10 Alternatively to this method variant, it is possible,  
11 furthermore, that the austenitized steel sheet blank, after  
12 being inserted into the press die, is first formed and held in  
13 complete contact with the press die, the press die being  
14 cooled at least to approximately 70°C before the forming  
15 process. After the forming process, the further cooling of the  
16 formed steel sheet blank is carried out, with the press die  
17 open or outside the press die in the ambient air. In this  
18 case, it is assumed that the shock-like cooling of the  
19 austenitized formed steel sheet blank in the precooled press  
20 die leads not only to the formation of the fundamental  
21 hardness structure, but also to a sufficient dimensional  
22 stability of the three-dimensional armoring component  
23 produced. In this case, the press die can be used at a higher  
24 frequency for the production of components with repeating  
25 accuracy.

26

27 Preferably, the steel sheet blanks used are sheets of  
28 hardenable and maraging steels.

29 The method provides for the initial hardness of the armoring  
30 steel during hardening in hardening oil to be higher than 45  
31 HRC or for the hardness after artificial ageing to be higher  
32 than 45 HRC.

33 Three-dimensionally formed armoring components with high  
34 dimensional accuracy are obtained, in particular, in that,  
35 after the forming operation, the press die is held closed for  
36 a period of time of 50 to 500 seconds until the desired  
37 cooling temperature is reached. As a result, the component is  
38 held in calibration up to the complete formation of the

1 hardness structure, as a consequence of which deformations due  
2 to thermal stresses can be largely ruled out.

3 The cooling rate via the contact of the formed steel sheet  
4 blank with the press die is influenced in that the press die  
5 consists of highly thermally conductive material, for example  
6 steel, and/or can be cooled by coolants, preferably, for  
7 example, water, ammonia and/or compressed air.

8

9 It is possible to subject the cooled and formed steel sheet  
10 blanks to final heat treatment in the form of an expansion  
11 and/or tempering process, annealing or age-hardening  
12 treatment.

13

14 Alternative to this, measures, such as hardening, age  
15 hardening or artificial ageing, are also possible as thermal  
16 retreatment procedures, depending on the alloy composition.  
17 These measures serve for compensating possible uneven  
18 distributions of the degrees of hardness in the component and  
19 consequently to rule out unreliability in safety against the  
20 effects of bombardments or explosions. The thermal distortion  
21 occurring during thermal retreatment is known to be about only  
22 10% of the armoring components produced by means of welding  
23 technology.

24 It is particularly advantageous that hot forming and quench  
25 hardening of the austenitized or partly austenitized steel  
26 sheet blanks are carried out in one operation.

27

28 The advantages of the invention, when combined, are that, for  
29 the special case of the production of three-dimensionally  
30 formed armoring components for vehicle bodies, specific  
31 requirements regarding the production of hardened steels, such  
32 as are known for the production of tools or semifinished  
33 products, do not have to be fulfilled. This refers, for  
34 example, to resistance to rolling fatigue, wear resistance or  
35 the fatigue limit under alternating stresses.

36 It may be assumed that the body of a vehicle of the special  
37 protection class is distorted completely or at least in  
38 respect of the loaded armoring components after being

1 subjected for the first time to load by bombardment or  
2 explosion. In light of these particular requirements, the  
3 armoring components to be produced must have, in particular,  
4 continuous or full-area quality and, if possible, not require  
5 a mechanical remachining of the surface of the  
6 three-dimensionally formed armoring component. The proposed  
7 method takes these particular requirements into account to a  
8 high degree. As compared with known welded structures,  
9 three-dimensionally formed armoring components of high quality  
10 are obtained in a comparatively simple way by conjoining a hot  
11 forming process with a hardening process, starting from sheet  
12 blanks which have previously been pretreated in an  
13 austenitized or partly austenitized state.

14  
15 In accordance with the desired protection class, characterized  
16 by defined bombardment safety and possible safety against  
17 explosions, the aim is to achieve the required heat treatment  
18 parameters.

19 Some annealing steels for use in protective class VR6 in this  
20 case, by the application of the proposed method, achieve, even  
21 without subsequent heat treatment, all the protective  
22 requirements, including safety against explosions by hand  
23 grenades of the type DM51, without splinter outbursts on the  
24 rear side of armoring elements.

25 In the design of the press dies, care must be taken to ensure  
26 that sufficient heat dissipation can be ensured at every point  
27 on the formed steel sheet blank. Furthermore, the flow  
28 properties of the material must be borne in mind, so that,  
29 during the forming operation, the component comes to bear  
30 under uniform surface pressure completely and uniformly  
31 against the impression of the die and thinnings of the  
32 material thickness are avoided. To stabilize the component  
33 during heat treatment, beads or stabilizing forms extending  
34 continuously may be embossed in the blank. After the hot  
35 pressing or possible heat treatment, the final form of the  
36 component is cut out by means of a laser or preferably a water  
37 jet.

38 By means of the proposed method, then, three-dimensionally

1 formed armoring components for different protection classes  
2 can be produced, and their wall thickness may even amount to  
3 more than 10 mm. By hot forming, then, armoring components for  
4 vehicle bodies can be implemented, which it has hitherto been  
5 possible to produce only as complicated welding structures  
6 with ballistic weak points in the weld seam region.  
7 Owing to the high process reliability, the large-series use of  
8 the method for the production of three-dimensionally formed  
9 armoring components with high dimensional accuracy is  
10 possible.

11  
12 The invention will be explained in more detail below by means  
13 of implementation examples.

14  
15 **Implementation Example 1:**  
16 A steel sheet with a thickness of 6.5 mm has the following  
17 content of alloying elements:

18  
19       0.5%           C  
20       1.1 - 1.3%    Ni  
21       1.0 - 1.5%    Si  
22       0.5 - 0.6%    Mn  
23       0.1 - 0.5%    Mo.

24  
25 From this steel sheet, a sheet blank is obtained and is heated  
26 to an austenitizing temperature in the amount of 950°C. In  
27 this state, the sheet blank is inserted into the press die and  
28 is formed as a result of the closing of the press die. Within  
29 a total of 300 seconds, the quench cooling of the formed steel  
30 sheet blank to the die temperature takes place. The die may in  
31 this case be cooled by coolant. The closing pressure of the  
32 press die is maintained over the entire cooling time.

33 Subsequently, heat treatment takes place by annealing to the  
34 quality HRC 50. The three-dimensionally formed armoring  
35 component corresponds to bombardment class VR6, this having  
36 been demonstrated by bombardment tests.

37  
38 **Implementation Example 2:**

1 A steel sheet blank with a thickness of 6.5 mm has the  
2 following fractions of alloying elements:

3  
4 0.25 - 0.4 % C  
5 0.0 - 1.0 % Ni  
6 0.2 - 0.4 % Si  
7 0.0 - 2.0 % Mn  
8 0.0 - 0.55% Mo  
9 0.0 - 1.1 % Cr.

10  
11 This steel sheet blank is heated to an austenitizing  
12 temperature in the amount of 970°C and is immediately inserted  
13 into the press die and formed as a result of the closing of  
14 the press die. The press die has previously been cooled to  
15 approximately 70°C. As a result of the shock-like cooling due  
16 to the optimized dissipation of a large part of the heat from  
17 the steel sheet blank to the press die, the formation of a  
18 sufficient hardness structure occurs. Consequently, after the  
19 conclusion of the forming operation, the press die can be  
20 opened and the further cooling of the three-dimensionally  
21 formed armoring component can be carried out at room  
22 temperature.

23 A subsequent heat treatment is dispensed with. The  
24 three-dimensionally formed armoring component obtained  
25 corresponds to bombardment class VR6, this having been  
26 demonstrated by bombardment tests.